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(54) **OIL SUPPLY UNIT AND MOTOR VEHICLE**

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F01M 11/00	(2006.01)

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CPC ***F01M 5/025*** (2013.01); ***F01M 1/02*** (2013.01); ***F01M 1/16*** (2013.01); ***F01M 11/0004*** (2013.01); ***F01M 11/02*** (2013.01); *F01M 5/02* (2013.01); *F01M 5/021* (2013.01); *F01M 2001/0253* (2013.01); *F01M 2005/028* (2013.01)

(58) **Field of Classification Search**

CPC F01M 5/025; F01M 2005/026; F01M 2005/028

See application file for complete search history.

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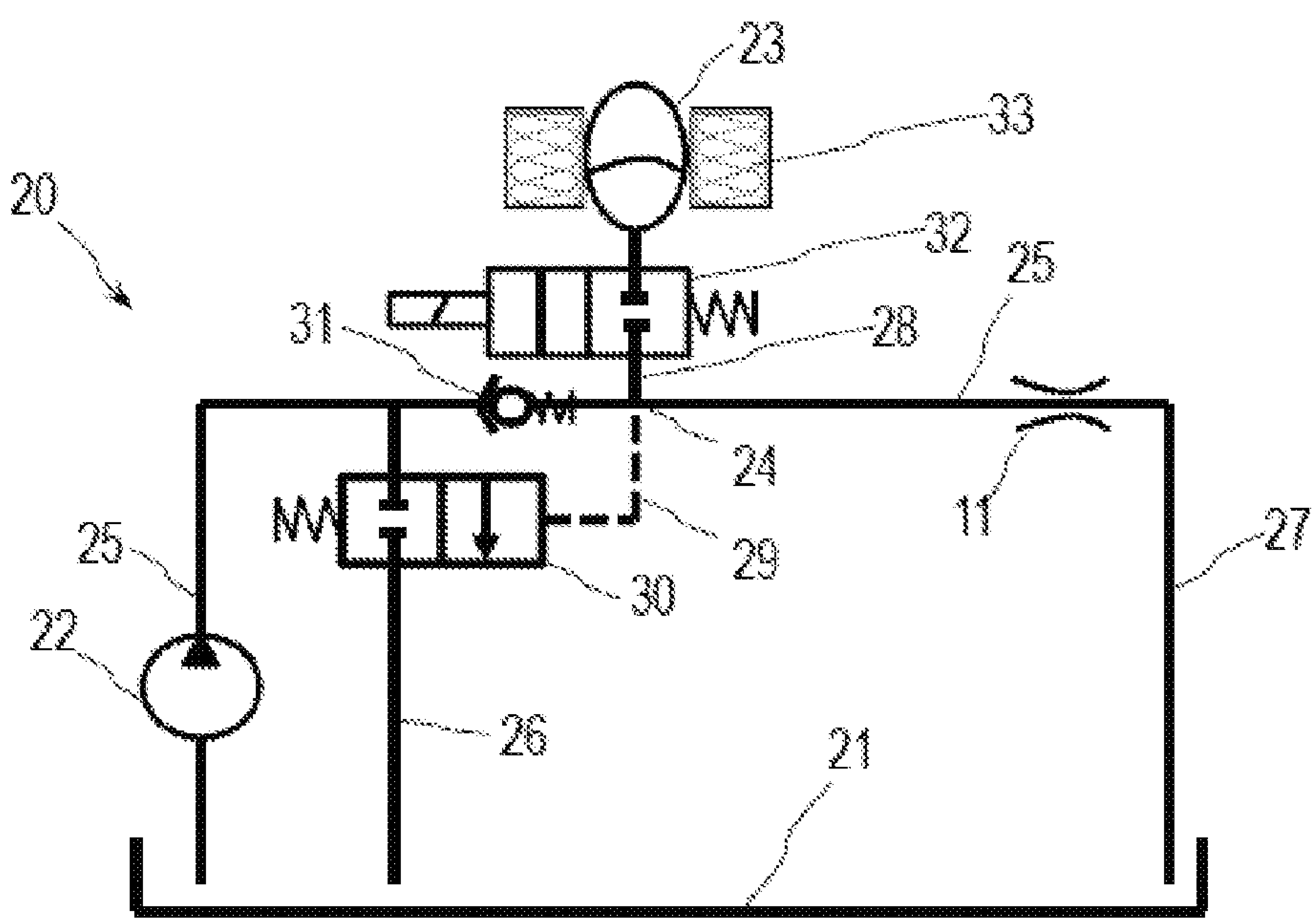
(57) **ABSTRACT**

Methods and systems are provided for an oil supply unit with a collecting vessel for collecting oil. In one example, a method may include maintaining a pressure of the collecting vessel during an engine off, wherein maintaining the pressure may further include maintain a temperature of the oil in the collecting vessel.

15 Claims, 5 Drawing Sheets



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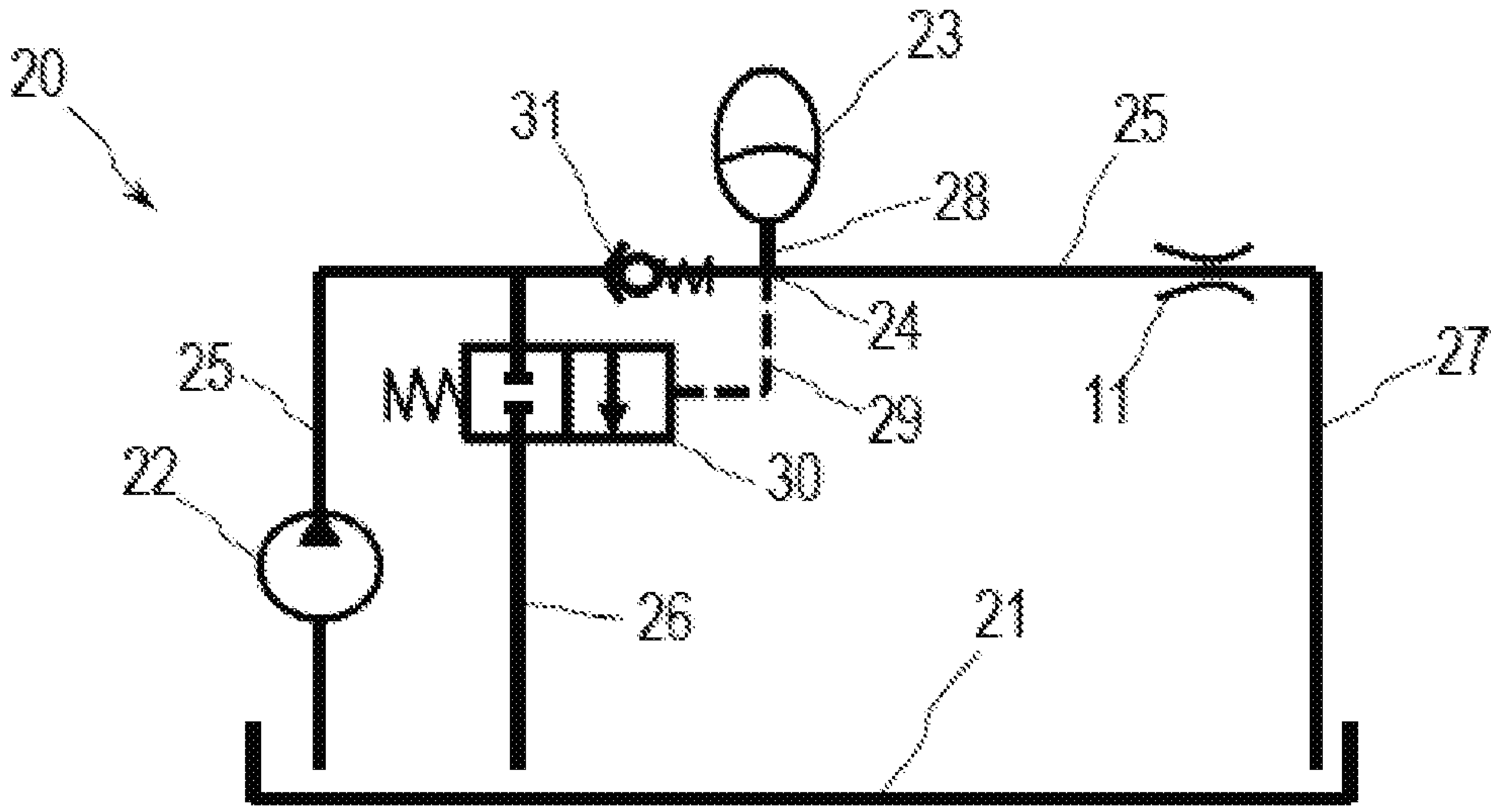
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FIG. 1

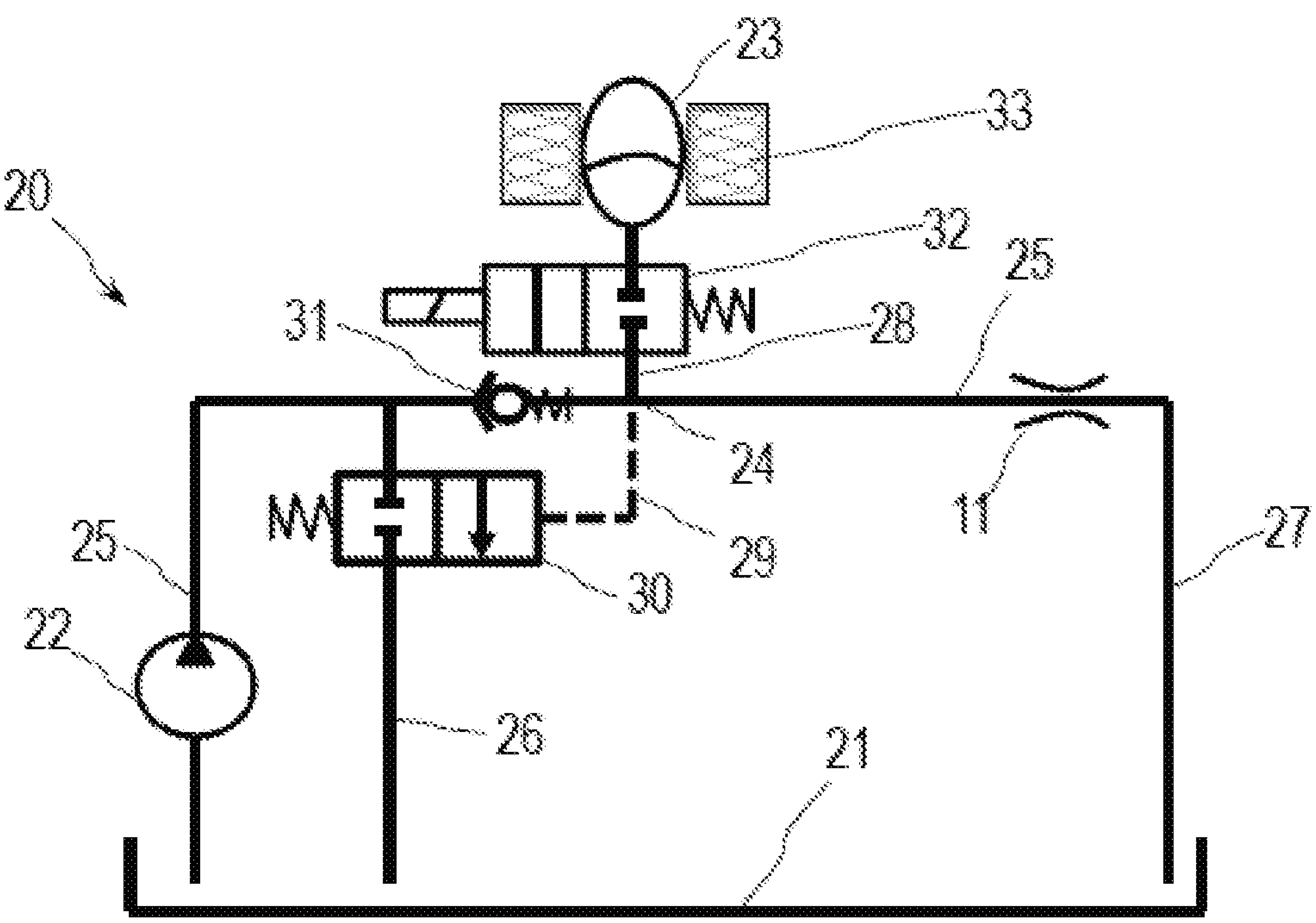
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FIG. 2

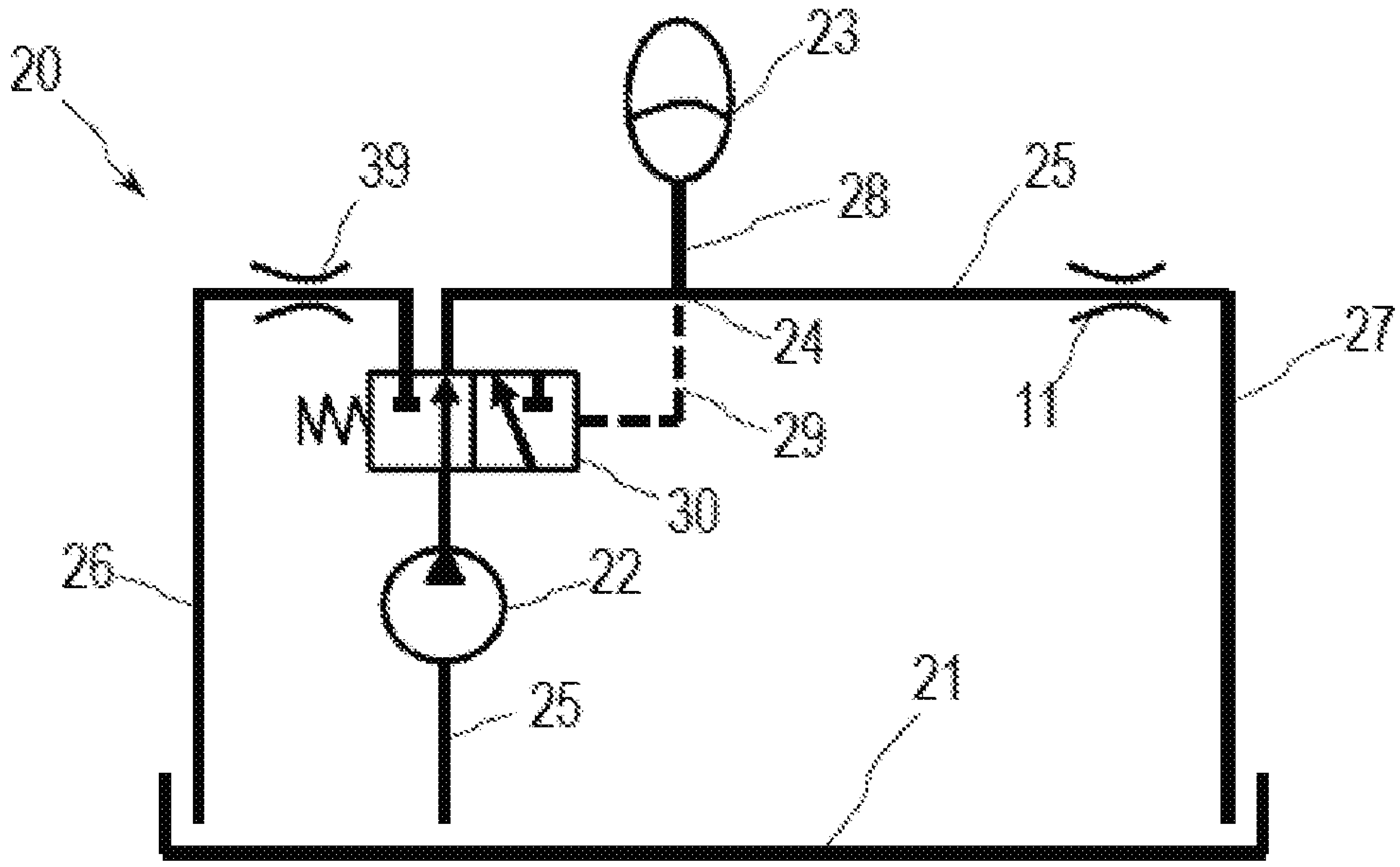
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FIG. 3

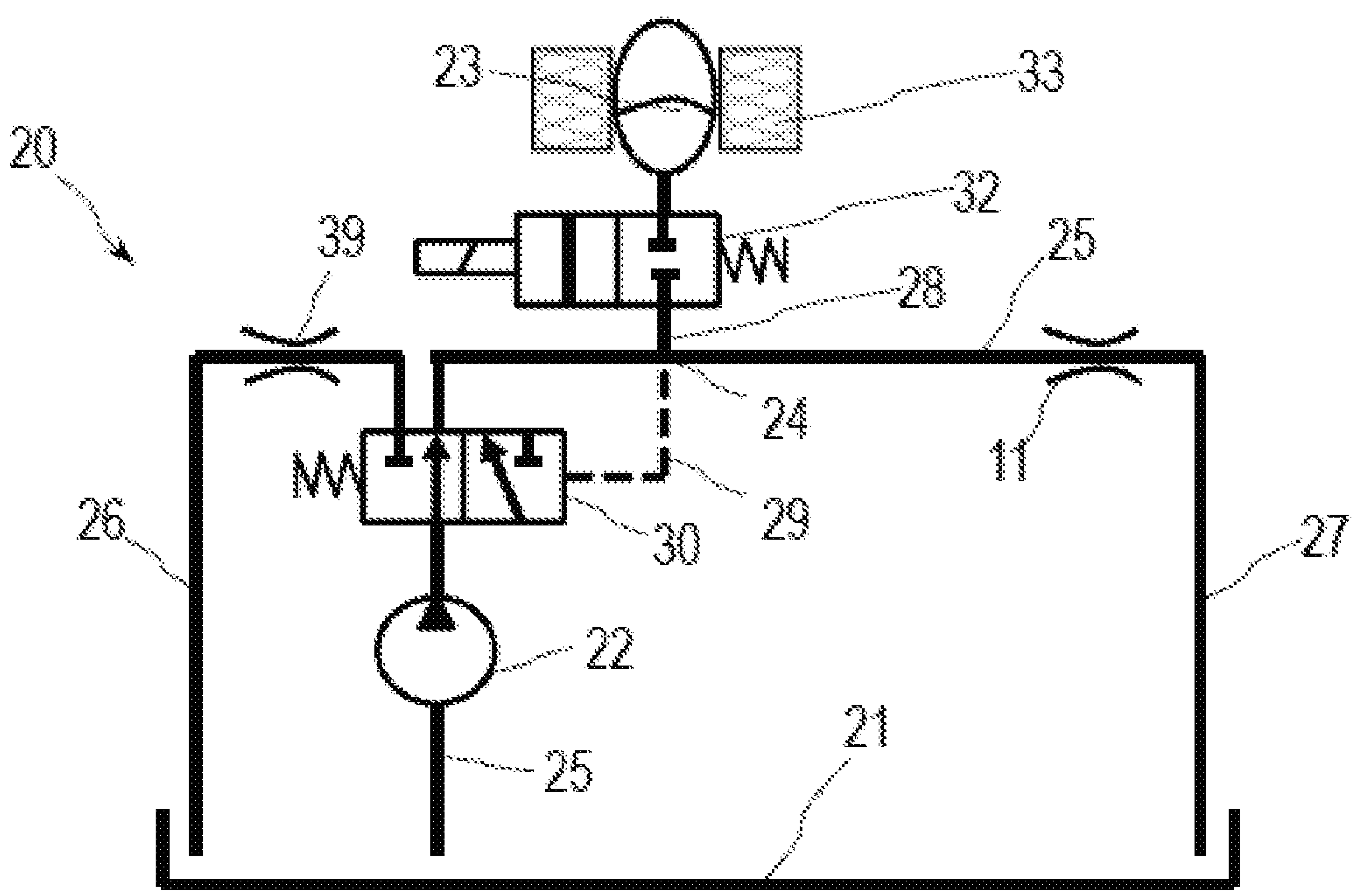
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FIG. 4

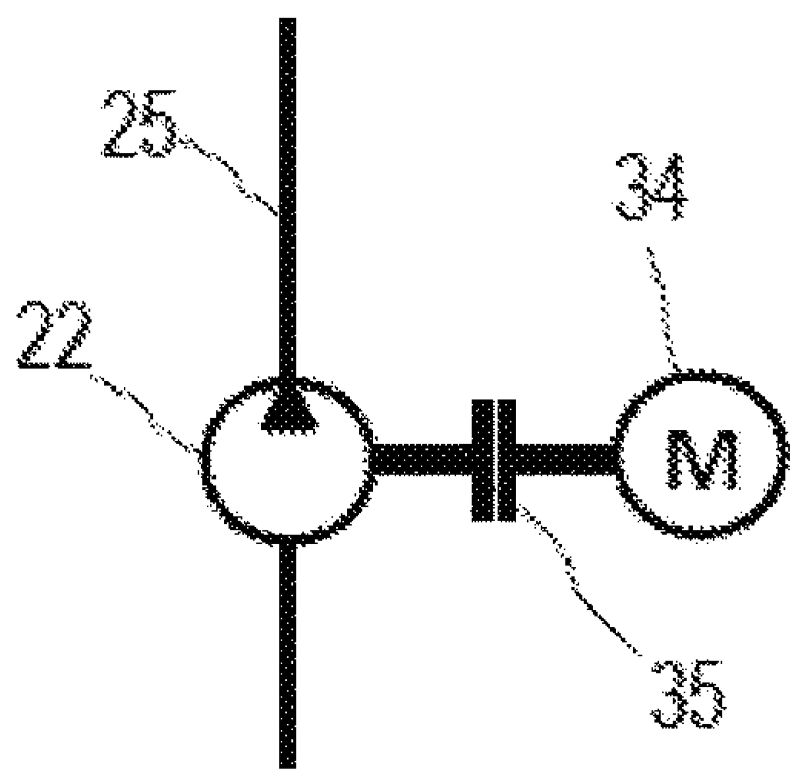

FIG. 5

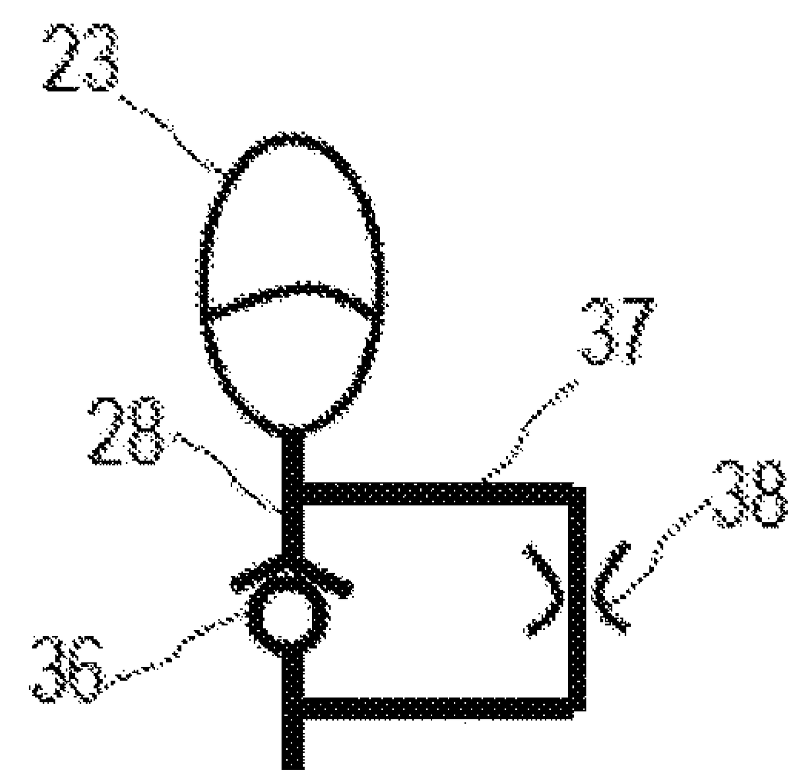

FIG. 6

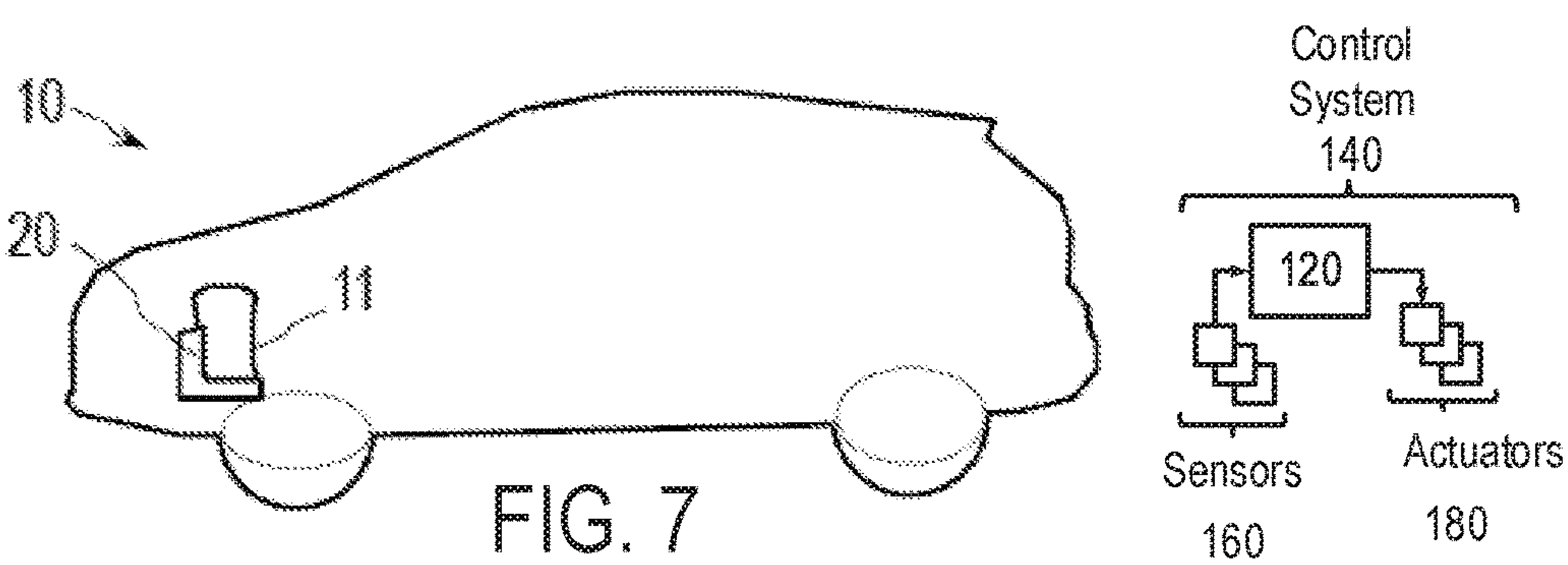

FIG. 7

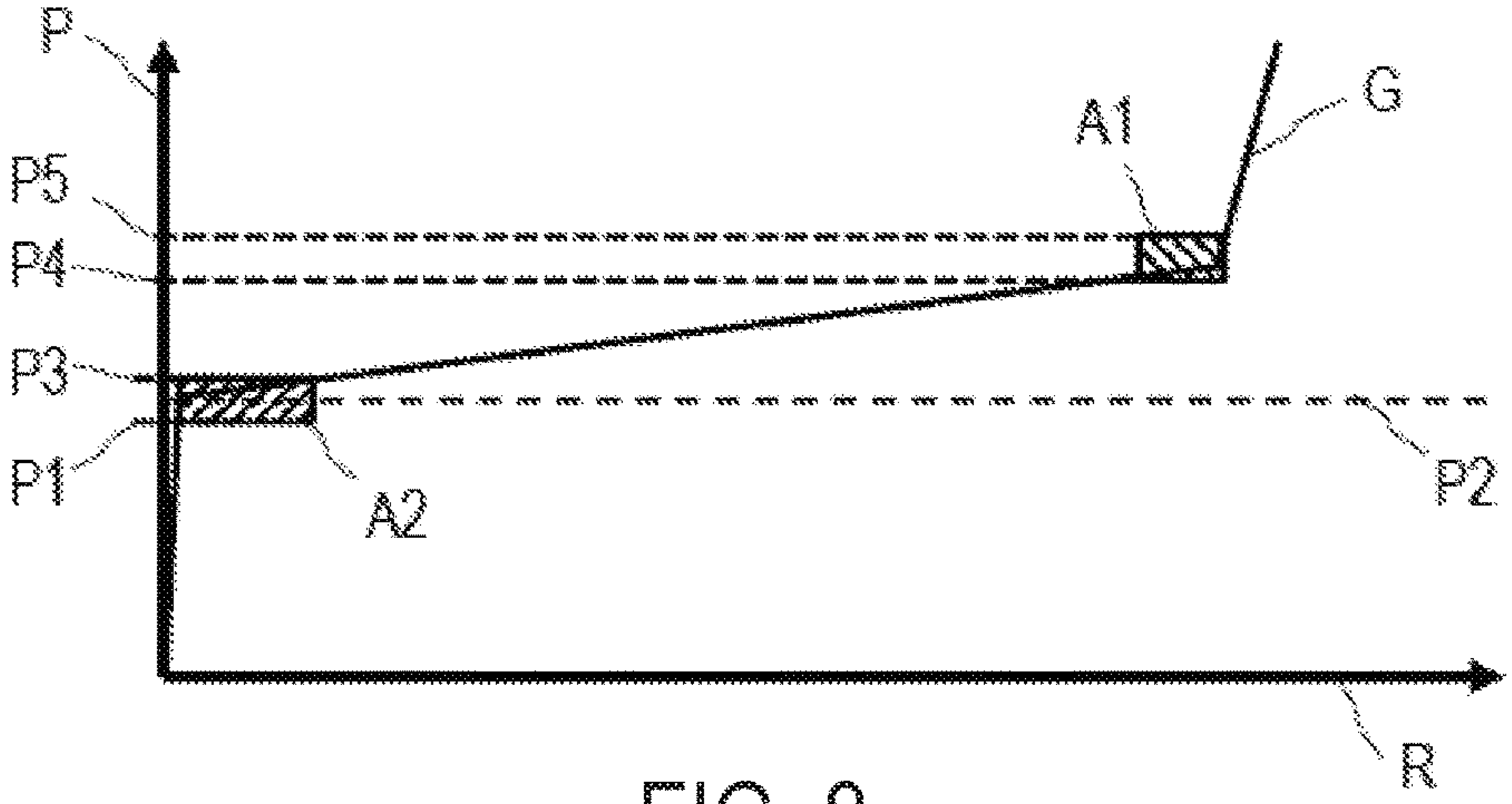

FIG. 8

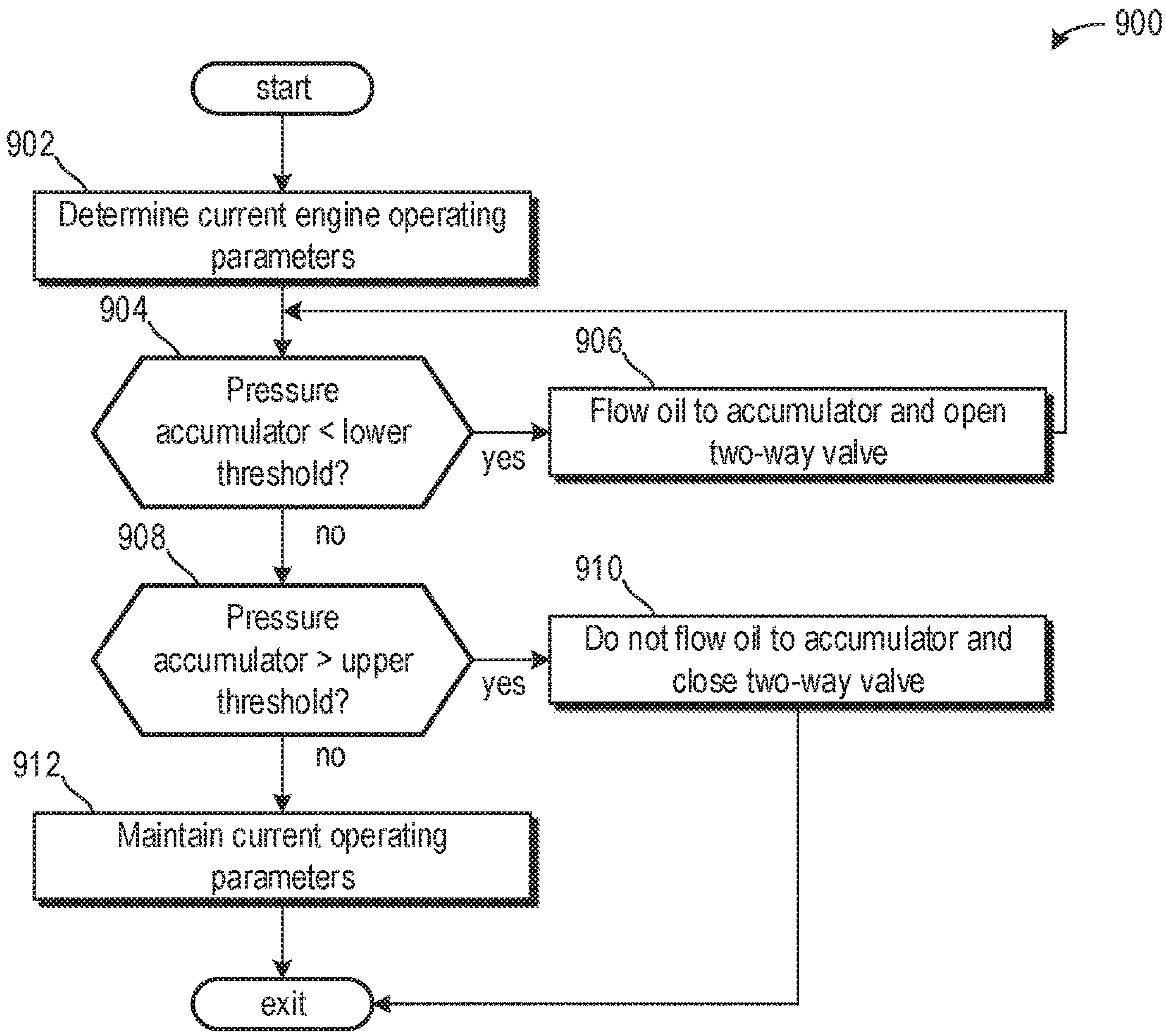
900
start
902
Determine current engine operating parameters
904
Pressure accumulator < lower threshold?
yes
906
Flow oil to accumulator and open two-way valve
no
908
Pressure accumulator > upper threshold?
yes
910
Do not flow oil to accumulator and close two-way valve
no
912
Maintain current operating parameters
exit

FIG. 9

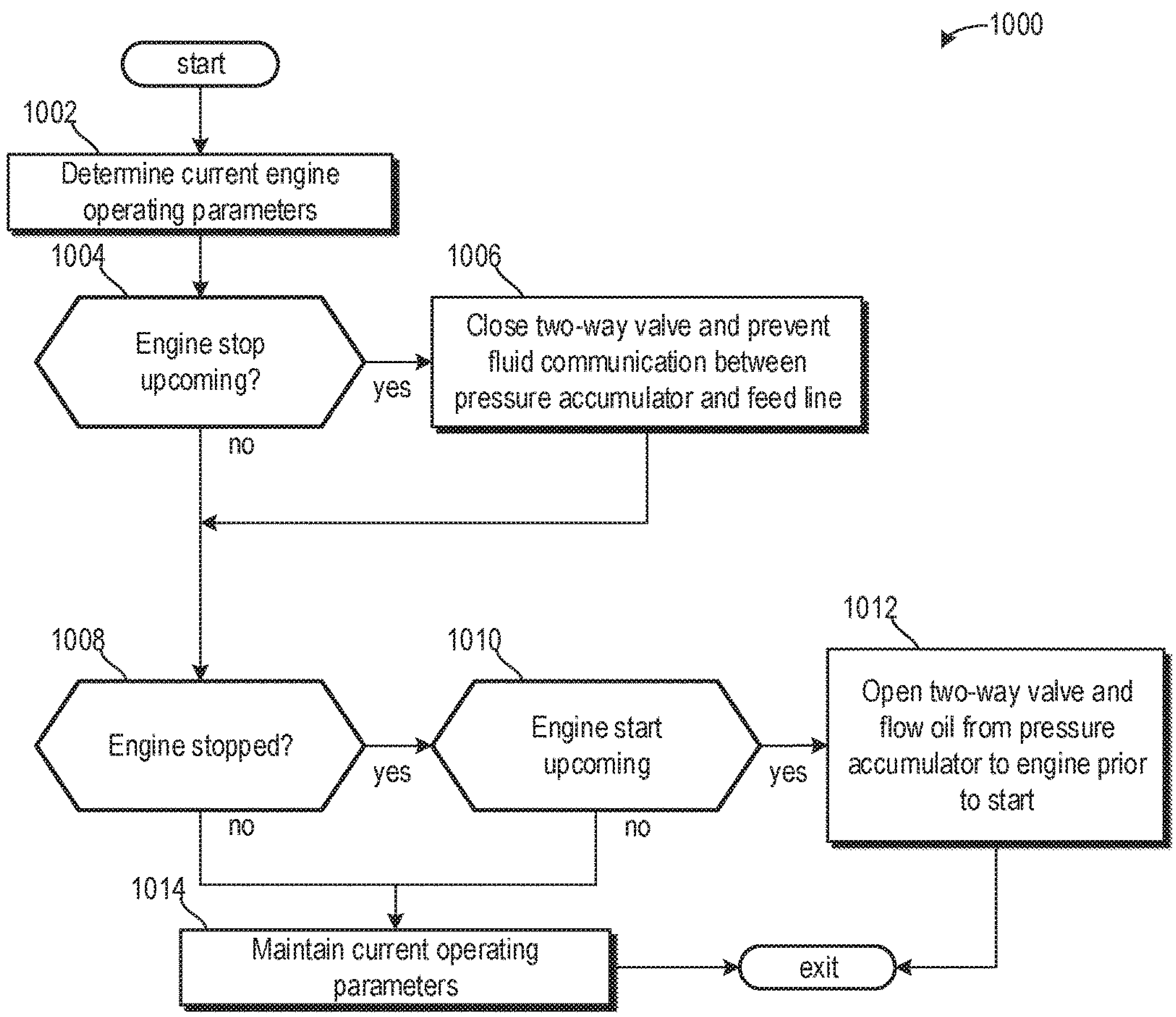
1000
start
1002
Determine current engine operating parameters
1004
Engine stop upcoming?
yes
no
1006
Close two-way valve and prevent fluid communication between pressure accumulator and feed line
1008
Engine stopped?
yes
no
1010
Engine start upcoming
yes
no
1012
Open two-way valve and flow oil from pressure accumulator to engine prior to start
1014
Maintain current operating parameters
exit

FIG. 10

OIL SUPPLY UNIT AND MOTOR VEHICLE

CROSS REFERENCE TO RELATED APPLICATION

The present application claims priority to German Patent Application No. 102016218835.6, filed Sep. 29, 2016. The entire contents of the above-referenced application are hereby incorporated by reference in its entirety for all purposes.

FIELD

The present description relates to an oil supply unit for a motor vehicle and also to a motor vehicle having this oil supply unit.

BACKGROUND/SUMMARY

In the prior art, a method for the oil supply of an internal combustion engine is known from DE 102009015450 A1, wherein an oil pump continuously supplies the operating internal combustion engine with oil. A pressurized quantity of oil from a tank temporarily supplies the internal combustion engine with oil when this is started. The oil pump can be operated in at least two stages in this case. The oil pump is operated at a low oil pressure in order to supply the operating internal combustion engine continuously with oil, and the oil pump is operated briefly at a high oil pressure in order to additionally store a pressurized quantity of oil in the tank while the internal combustion engine is in operation.

The present disclosure is based on the object of providing an improved oil supply unit and also a motor vehicle having this oil supply unit.

This object is achieved by means of an oil supply unit as claimed in claim **1** and also by means of a motor vehicle as claimed in claim **12**. The oil supply unit according to the disclosure comprises a collecting vessel for collecting oil, a feed line which leads from the collecting vessel to an engine which is to be supplied with oil, a pump which is arranged in the feed line, a return line which leads from the engine to the collecting vessel, and a circulation line which leads from the feed line to the collecting vessel. According to the disclosure, the oil supply unit has a pressure accumulator which is connected via an accumulator line to the feed line and a two-way valve which can be switched in dependence of a pressure which prevails in the feed line. The two-way valve is in the first switched position in the case of a first pressure and is in the second switched position in the case of a second pressure which is higher than the first pressure. The circulation line is shut off in the first switched position of the two-way valve and opened in the second switched position of the two-way valve.

Therefore, an oil supply unit is provided in which the pressure accumulator acts with damping effect upon pressure fluctuations in the feed line. Moreover, by means of the pressure accumulator it is made possible to continue to supply the engine with oil even after a stoppage of the pump. Furthermore, by means of the pressure accumulator it is made possible to briefly provide a volumetric flow of oil which is greater than the possible volumetric flow which is to be delivered by the pump. Therefore, the pump can be of an altogether smaller design. This saves costs and weight.

The oil supply unit can be operated particularly efficiently since a changeover of the two-way valve into the second

switched position brings about an unpressurized pumping through the circulation line which can be carried out with comparatively little energy.

The oil supply unit according to the disclosure offers a flexible construction and is consequently easily adaptable to the respective installation space situation.

In an embodiment of the oil supply unit according to the disclosure, the pump has a constant displacement capacity.

A fixed displacement pump may be less likely to degrade than a pump with variable displacement capacity. The pump can be designed so that this operates constantly within a favorable range with a high degree of efficiency.

In a further embodiment of the oil supply unit according to the disclosure, the two-way valve is a two/two-way valve which is arranged in the circulation line. Alternatively, the two-way valve is a three/two-way valve which is arranged in the feed line and to which is also connected the circulation line.

Therefore, provision is made for two simply constructed and robust embodiments which offer a long service life and high reliability.

In a further embodiment of the oil supply unit according to the disclosure, the pressure accumulator is provided with a thermal insulation.

In this way, it is made possible to keep heat energy contained in the stored for a longer period. The oil supply unit can therefore serve as a heat accumulator and serve for temperature control, especially for quicker warming up of the engine, which positively influences the durability of the engine.

In a further embodiment of the oil supply unit according to the disclosure, a two-way valve is arranged in the accumulator line, wherein the accumulator line is opened in a first switched position of the accumulator-line two-way valve and shut off in a second switched position of the accumulator-line two-way valve.

After a shutdown of the motor which drives the pump, the accumulator line, by setting the accumulator-line two-way valve into the second switched position, can be shut off and emptying of the pressure accumulator can be prevented. During a restart of the oil supply unit, pressure can then be built up more quickly. If the motor is the engine itself which is to be supplied, the engine can also already be supplied with oil before its startup by setting the accumulator-line two-way valve into the first switched position. This may improve the durability of the engine especially in the case of motor vehicles with a stop/start automatic unit.

In a further embodiment of the oil supply unit according to the disclosure, the pump can be driven by the engine and the pump is functionally connected to the engine via a clutch. In particular, the oil supply unit is designed in this case in a way that the clutch can be operated in dependence of an oil pressure of the oil supply unit. Alternatively, the pump can be driven by an electric motor which in particular can be controlled or switched.

In this way, it is made possible to switch off the pump when not desired during the operation of the oil supply unit. It is made possible to decouple the drive of the pump, for example when the pressure accumulator has been sufficiently filled. By switching on or switching off the pump, it is possible to maintain a pressure level which is as constant as possible. The efficiency of the oil supply unit is therefore further increased.

In a further embodiment of the oil supply unit according to the disclosure, an accumulator-line check valve, which shuts off the inflow to the pressure accumulator, and a bypass which circumvents the accumulator-line check valve and in which comprises a bypass restrictor, are arranged in the accumulator line.

As a result, the inflow to the pressure accumulator is limited and the supply to the engine desired. The flow from the pressure accumulator to the feed line can be carried out almost without hindrance in the process.

The oil supply unit according to the disclosure may be integrated into a motor vehicle. The motor vehicle according to the disclosure has an engine which can be supplied with oil from the oil supply unit.

Therefore, the oil supply unit described above may benefit to the motor vehicle.

It should be understood that the summary above is provided to introduce in simplified form a selection of concepts that are further described in the detailed description. It is not meant to identify key or essential features of the claimed subject matter, the scope of which is defined uniquely by the claims that follow the detailed description. Furthermore, the claimed subject matter is not limited to implementations that solve any disadvantages noted above or in any part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows an oil supply unit according to the disclosure in a first variant in an exemplary first embodiment.

FIG. **2** shows the first variant of the oil supply unit in an exemplary second embodiment.

FIG. **3** shows the oil supply unit according to the disclosure in a second variant in an exemplary first embodiment.

FIG. **4** shows the second variant of the oil supply unit in an exemplary second embodiment.

FIG. **5** shows an exemplary drive of the oil supply unit.

FIG. **6** shows a detailed section of the oil supply unit.

FIG. **7** shows a motor vehicle according to the disclosure in an exemplary embodiment.

FIG. **8** shows an exemplary switching strategy of the oil supply unit.

FIG. **9** shows a method for adjusting a valve of the oil supply circuit.

FIG. **10** shows a method for operating the pressure accumulator during an engine stop and/or cold-start.

DETAILED DESCRIPTION

The following description relates to systems and methods for an oil supply unit having a pressure accumulator. The pressure accumulator may supply oil to the engine during instances when an oil pump is off and/or when oil pressure is low. The oil supply unit is shown in FIG. **1**. The oil supply unit is shown having a thermally insulating material in FIG. **2**. The oil supply unit is shown coupled to high-pressure portion of a high and low pressure system in FIG. **3**. The oil supply unit of FIG. **3** is shown having a thermally insulating material in FIG. **4**. A motor may be optionally used to operate the pump of the oil supply unit, as shown in FIG. **5**. A bypass passage to the pressure accumulator is shown in FIG. **6**. A vehicle having an engine coupled to the oil supply unit and a control system is shown in FIG. **7**. A graph depicting a switching strategy for a two-way valve coupling the pressure accumulator to a feed line is shown in FIG. **8**. A method for adjusting the two-way valve for maintaining a pressure in the pressure accumulator is shown in FIG. **9**. A method for using the pressure accumulator during an engine stop and/or cold-start is shown in FIG. **10**.

Shown schematically in FIG. **7** is the motor vehicle **10** according to the disclosure in an exemplary embodiment. The motor vehicle **10** comprises an engine **11** which is to be supplied with oil. The engine **11** is particularly an internal combustion engine. According to the disclosure, the motor vehicle **10** comprises an oil supply unit **20** according to the disclosure which is designed to supply the engine **11** with oil, wherein oil is fed to the engine at a specified pressure.

The motor vehicle **10** may further include control system **140**. Control system **140** is shown receiving information from a plurality of sensors **160** (various examples of which are described herein) and sending control signals to a plurality of actuators **180** (various examples of which are described herein). As one example, sensors **160** may include an exhaust gas sensor (located in an exhaust manifold), temperature sensor, intake manifold pressure transducer, and exhaust pressure transducer. Other sensors such as additional pressure, temperature, air/fuel ratio, and composition sensors may be coupled to various locations in the motor vehicle. As another example, the actuators may include fuel injectors, throttle, boost level output by turbocharger, etc. The control system **140** may include a controller **120**. The controller may receive input data from the various sensors, process the input data, and trigger the actuators in response to the processed input data based on instruction or code programmed therein corresponding to one or more routines. One example routine is shown with reference to FIG. **9**.

The controller **120** receives signals from the various sensors described above and employs the various actuators to adjust engine operation based on the received signals and instructions stored on a memory of the controller. For example, adjusting pressure accumulation of the oil supply unit may include adjusting an actuator of a two-way valve to adjust oil flow through an oil flow system.

In the sense of this disclosure oil may include all liquid lubricants.

The oil supply unit **20** according to the disclosure is shown schematically in FIGS. **1** to **4** in two different variants in two different exemplary embodiments in each case.

The oil supply unit comprises a collecting vessel **21**, such as an oil sump, for storing and collecting the oil. The oil supply unit **20** furthermore comprises a feed line **25**, a circulation line **26** and a return line **27**.

The feed line **25** leads from the collecting vessel **21** to the engine **11**. The feed line **25** is connected to the collecting vessel **21** and to the engine **11** with fluid conducting effect. The feed line **25** is designed to conduct oil from the collecting vessel **21** to the engine **11**. Herein, fluid conducting effect may refer to a pressure relationship between two or more components, where fluid flows from a high pressure area to a low pressure area.

The circulation line **26** leads from the feed line **25** to the collecting vessel **21**. The circulation line **26** is connected, or can be connected, to the feed line **25** with fluid conducting effect. The circulation line **26** is connected to the collecting vessel **21** with fluid conducting effect. The circulation line **26** is designed to conduct oil from the feed line **25** to the collecting vessel **21**.

The return line **27** leads from the engine **11** to the collecting vessel **21**. The return line **27** is connected to the engine and to the collecting vessel **21** with fluid conducting effect. The return line **27** is designed to conduct oil from the engine **11** to the collecting vessel **21**.

The oil supply unit is provided with a pump **22** which is arranged in the feed line **25**. The pump **22** may be a fixed displacement pump and therefore has a constant displacement capability. The pump **22** can be driven by a motor **34**, shown in FIG. **5**. An actuator of the motor **34** may be electrically coupled to a controller (e.g., controller **120** of FIG. **1**). The pump **22** may not be permanently driven during the operation of the oil supply unit **20**. To this end, the drive can comprise an electric motor which can be controlled or at least switched. The electric motor can therefore be operated when desired. Alternatively, the pump **22** can be driven by means of a motor **34** which operates permanently during the operation of the oil supply unit **20**. The pump **22** in this case can be connected to the motor **34** via a clutch **35** when desired. The clutch **35** maybe operated in dependence of an oil pressure of the oil supply unit **20**. The engine **11** is the motor **34**, in one example.

The oil supply unit **20** has, according to the disclosure, a pressure accumulator **23** and an accumulator line **28**. The accumulator line **28** is arranged between the pressure accumulator **23** and the feed line **25**. The accumulator line **28** is connected to the pressure accumulator **23** with fluid conducting effect. The accumulator line **28** is connected to the feed line **25** with fluid conducting effect at a connection point **24**. The accumulator line **28** is designed to conduct oil from the feed line **25** to the pressure accumulator **23** and also from the pressure accumulator **23** to the feed line **25**. The pressure accumulator **23** is especially preloaded to a specified system pressure. The pressure accumulator **23** is especially designed as a piston accumulator with a pressure chamber and a rearward open chamber so that the filling degree of the pressure accumulator does not in essence influence an oil filling level. The rearward chamber is connected in this case to the collecting vessel **21** with fluid conducting effect. The pressure accumulator **23** can also be provided with a thermal insulation **33** (as shown in FIG. **2**). The thermal insulation **33** may comprise a gap arranged around the pressure accumulator **23** or a thermally insulating material (e.g., rubber, cloth, and the like). For example, the pressure accumulator **23** may comprise a double walled outer shell with one or more of air and water arranged therebetween. The air and/or water may act as a thermal barriers between contents arranged interior to the pressure accumulator **23** and a thermal environment outside of the pressure accumulator **23**. Additionally or alternatively, a vacuum may be arranged between the walls of the double walled outer shell.

Moreover, the oil supply unit **20** can have an accumulator-line check valve **36**, a bypass **37** and a bypass restrictor **38**. The accumulator-line check valve **36** is in this case arranged in the accumulator line **28** in a way that an inflow to the pressure accumulator **23** through the accumulator line **28** is shut off. The inflow to the pressure accumulator **23** is enabled in this case by means of the bypass **37** which is arranged to circumvent the accumulator-line check valve **36**. The bypass restrictor **38**, which restricts the inflow to the pressure accumulator **23**, can be arranged in the bypass **37**.

The oil supply unit **20** also comprises, according to the disclosure, a two-way valve **30** which can be selectively switched into two switched positions. The two-way valve **30** is especially connected to a control line **29** which picks up the pressure in the feed line **25**. The two-way valve **30** can be switched in dependence of the pressure which prevails in the feed line **25**. Therefore, the two-way valve **30** has a first switched position in the case of a first pressure in the feed line **25** and has a second switched position in the case of a second pressure. The first pressure in this case is lower than the second pressure. In the first switched position, the circulation line **26** is shut off so that no oil can make its way from the feed line **25** via the circulation line **26** to the collecting vessel. In the second switched position, the circulation line **26** is opened so that oil can make its way from the feed line **25** via the circulation line **26** to the collecting vessel.

The present disclosure provides two variants of the oil supply unit **20**. The first variant is shown in FIGS. **1** and **2** and the second variant is shown in FIGS. **3** and **4**.

In the first variant, the two-way valve **30** is arranged in the circulation line **26** and is designed as a two/two-way valve, that is to say with two connection points. The circulation line **26** is connected to both connection points. In the first switched position, both connection points are blocked in this case. A flow through the two-way valve is prevented. The first switched position is shown in FIGS. **1** and **2**. In the second switched position, both connection points are interconnected in this case. A flow through the second switch position of the two-way valve **30** is enabled.

Between the point at which the circulation line **26** branches from the feed line **25** and the connection point **24** at which the accumulator line **28** leads into the feed line **25**, a check valve **31** is arranged in the feed line **25** in the first variant in order to prevent oil being able to make its way from the pressure accumulator **23** through the circulation line **26** to the collecting vessel **21**. The check valve **31** can be designed with or without a spring.

In the second variant, the two-way valve **30** is arranged in the feed line **25** and is designed as a three/two-way valve, that is to say with three connection points. The circulation line **26** is connected to a first of the three connection points. The feed line **25** is connected to a second and a third of the three connection points. In the first switched position, the first connection point is blocked in this case and a connection is made between the second and third connection points. A flow through the three/two-way valve from a portion of the feed line **25** upstream of the pump **22** to a portion of the feed line **25** leading to the engine **11** is enabled. The circulation line **26** is connected to the feed line **25** in the first switched position with no fluid-conducting effect in this case. Said another way, in the first switched position, the first of the three connection points is closed, thereby reducing and/or preventing fluid flow from the circulation line to the feed line **25**. The first switched position is shown in FIGS. **3** and **4**. In the second switched position, the first and the second connection points are interconnected with fluid-conducting effect in this case. A flow through the three/two-way valve from the portion of the feed line **25** upstream of the pump **22** to the circulation line **26** is enabled. The portion of the feed line **25** leading to the engine **11** is connected to the pump-side feed line **25** in the second switched position with no fluid-conducting effect in this case. Said another way, when the three/two-way valve is in the second switched position, fluid may not flow from the pump **22** to the engine **11**.

The circulation line **26** can be in communication with a low-pressure system **39**. It is in the manner shown in FIGS. **3** and **4**. If the two-way valve **30** is in the second switched position, then the pump **22** performs work for the low-pressure system **39**. The low-pressure system **39** is for example a tank system.

As an option, the oil supply unit **20** can have an accumulator-line two-way valve **32** in both variants. It is in the manner shown in FIGS. **2** and **4**. The accumulator-line two-way valve **32** is a two/two-way valve with two connection points and two switched positions. The accumulator line **28** is connected to both connection points. In a first switched position, a flow through the accumulator-line two-way valve **32** is enabled and the accumulator line **28** is opened.

In a second switched position, flow is prevented and the accumulator line **28** is shut off. The second switched position is shown in FIGS. **2** and **4**. In one example, when the two-way valve **32** is in the first switched position, the accumulator line **28** flows fluid from the pressure accumulator **23** to the feed line **25**. Thus, when the two-way valve **32** is in the second switched position, the accumulator line **28** flows less or prevents fluid flow from the pressure accumulator **23** to the feed line **25**.

Shown in FIG. **8** is an exemplary switching strategy for the two-way valve **30**. In this case, the pressure P inside the pressure accumulator **23** is mapped against a filling level R of the pressure accumulator. Based on the two-way valve **30** being in the first switched position, the pressure P rises in the pressure accumulator **23** up to a preload pressure P**2**, while the pump **22** is in operation and has an output volume which is greater than that demanded by the engine **11**—see graph G. From the preload pressure P**2** onward, the pressure P rises corresponding to a spring characteristic of a preload device of the pressure accumulator **23** which exerts the preload. Progressing further, the pressure P rises in proportion to the filling level R up to the point at which the pressure accumulator **23** is completely filled. At this point, between a fourth pressure P**4** and a fifth pressure P**5**, the first switching range A**1** is formed. In the first switching range A**1**, the two-way valve **30** is switched from the first switched position into the second switched position. Supplying the engine **11** with oil now takes place with the oil stored in the pressure accumulator **23**, wherein the pressure P in the pressure accumulator **23** falls again and the filling level R decreases. Between a first pressure P**1** and a third pressure P**3**, a second switching range A**2** is formed. The preload pressure P**2** lies between the first pressure P**1** and the third pressure P**3**. In the second switching range A**2**, the two-way valve **30** is switched from the second switched position into the first switched position. Supplying the engine **11** with oil now takes place with the oil which is delivered by the pump **22**, wherein the pressure P in the pressure accumulator **23** rises again and the filling level R increases.

Controlling of the valves **30**, **32**, of the clutch **35** and/or of the motor **34** can be carried out by means of a control unit to which pressure signals of the oil supply unit **20** are made available.

Turning now to FIG. **9**, it shows a method **900** for adjusting oil flow to and from the pressure accumulator. Instructions for carrying out method **900** and the rest of the methods included herein may be executed by a controller based on instructions stored on a memory of the controller and in conjunction with signals received from sensors of the engine system, such as the sensors described above with reference to FIG. **7**. The controller may employ engine actuators of the engine system to adjust engine operation, according to the methods described below.

The method **900** begins at **902** where the method includes determining, estimating, and measuring engine operating parameters. Engine operating parameters may include but are not limited to one or more of manifold pressure, throttle position, engine speed, vehicle speed, exhaust gas recirculation flow rate, engine temperature, and air/fuel ratio.

At **904**, the method **900** may include determining if a pressure of the pressure accumulator is less than a lower threshold. In one example, the lower threshold is a non-zero value. The lower threshold may be based on a pressure of the pressure accumulator where the pressure accumulator is unable to flow lubricant to the engine when the pump is off. Additionally or alternatively, the lower threshold is substantially equal to the pressure value of preload pressure P**2** of FIG. **8**. In one example, the lower threshold pressure corresponds to a pressure accumulator being 20 to 30% full of oil.

If the pressure of the pressure accumulator is less than the lower threshold, then the method **900** proceeds to **906** to flow oil to the accumulator. This may include opening the two-way valve in the circulation line (e.g., two-way valve **30** in circulation line **26** of FIGS. **1** and **2**). Additionally or alternatively, an accumulator line two-way valve (e.g., accumulator line two-way valve **32** of FIGS. **2** and **4**) may be opened. By opening these two-way valves, the pressure accumulator may be fluidly coupled to portions of the oil supply unit. The method continues to monitor the pressure of the pressure accumulator. When the pressure of the pressure accumulator is less than the lower threshold, the pump (e.g., pump **22** of FIG. **2**) is the sole provider of oil to the engine. Said another way, the pressure accumulator may not provide oil to the engine when its pressure is less than the lower threshold.

If the pressure of the pressure accumulator is greater than the lower threshold, then the method **900** proceeds to **908** to determine if the pressure of the pressure accumulator is greater than an upper threshold. In one example, the upper threshold is equal to a non-zero value. Specifically, the upper threshold may be equal to a pressure between the fourth pressure P**4** and the fifth pressure P**5** of FIG. **8**. Additionally or alternatively, the upper threshold may be equal to a pressure corresponding to a pressure accumulator being 80-90% full of lubricant (e.g., oil).

If the pressure of the pressure accumulator is greater than the upper threshold, then the method **900** may proceed to **910** to not flow oil to the accumulator. This may additionally include closing one or more of the two-way valves arranged in the accumulator line and the circulation line (e.g., two-way valves **32** and **30**, respectively, of FIG. **2**). As such, the pressure accumulator is sufficiently full of lubricant and is at a desired pressure. By closing the two-way valves, the pressure accumulator may not fluidly communicate with the oil supply unit. However, if only the two-way valve in the circulation line is closed and the two-way valve in the accumulator line is at least partially open, then the pressure accumulator may fluidly communicate with the engine (e.g., engine **11** of FIG. **2**). Fluidly communicate may be defined as fluid transfer between two or more components. In one example, when the pressure of the pressure accumulator is greater than the upper threshold, only the pressure accumulator flows lubricant to the engine. As such, the pump may not flow lubricant to the engine when the pressure of the pressure accumulator is greater than the upper threshold.

In some examples, additionally or alternatively, when the pressure of the pressure accumulator is greater than at least the lower threshold (e.g., may be greater than or less than the upper threshold), then the pressure accumulator and/or the pump may flow lubricant to the engine. In some example, the pump and the pressure accumulator may alternate in flowing lubricant to the engine. Additionally or alternatively, the pump and the pressure accumulator may work in tandem to flow lubricant to the engine. In one example, the accumulator line two-way valve may be adjusted between open and closed positions to adjust an amount of assistance provided by the pressure accumulator to the pump. Positions between the open and closed positions may be referred to as more open and more closed positions, where more open position allow more lubricant to flow from the pressure accumulator to the feed line than the more closed positions. As such, if a greater amount of assistance from the pressure accumulator is desired, then the accumulator line two-way valve may be move to a more open position or fully open position. In this way, the pump may be forced to provide less lubricant to the engine, thereby decreasing work done by the pump, and increasing fuel economy. This may be desired during higher engine loads when the pump is driven by the engine. By utilizing the pressure accumulator, more power output from the engine may be directed toward the wheels to meet a driver demand.

If the pressure in the pressure accumulator is less than the upper threshold and greater than the lower threshold, then the method **900** may proceed to **912** to maintain current engine operating parameters. When the pressure in the pressure accumulator is between the upper and lower threshold, the pressure accumulator may still be configured to flow oil to the engine. In this way, the pump and the pressure accumulator may alternate in feeding oil to the engine.

Turning now to FIG. **10**, it shows a method **1000** for maintain pressure in the pressure accumulator in response to an upcoming engine stop and flowing lubricant to the engine in response to an upcoming engine start.

The method **1000** begins at **1002** where the method includes determining, estimating, and/or measuring current engine operating parameters. Engine operating parameters may include but are not limited to one or more of manifold pressure, throttle position, engine speed, vehicle speed, exhaust gas recirculation flow rate, engine temperature, engine on or off, and air/fuel ratio.

At **1004**, the method **1000** may include determining if an engine stop is upcoming. An engine stop may be upcoming if one or more of an accelerator pedal is released (e.g., inclined) and a brake pedal is depressed (e.g., declined). The engine stop may include the engine cylinders no longer combusting. Additionally or alternatively, the engine stop may include an engine off, where the engine is no longer fueled and stops spinning.

Additionally or alternatively, the upcoming engine stop may be determined via a navigation system. For example, the navigation system may determine that the vehicle is approaching a stop light and an engine stop of a start/stop procedure. Furthermore, the navigation system may determine the destination of a route being reached (e.g., "home", "work", or the like).

At **1006**, the method **1000** may include preventing fluid communication between the pressure accumulator and the feed line. This may include closing the two-way valve in the circulation line and/or the two-way valve in the accumulator line. As such, the pressure in the pressure accumulator may be maintained when the engine stop occurs. As described above, the engine may function as the motor operating the pump. In this way, if the engine stops, then the pump may no longer deliver lubricant to the engine. Thus, upon an engine restart, lubricant flow to the engine may lag, resulting in insufficiently lubricated engine components. However, this may be prevented by maintaining the pressure of the pressure accumulator when the engine is stopped so that when an engine restart is upcoming the pressure accumulator may prematurely flow lubricant to the engine.

Additionally, since the pressure accumulator may be thermally insulated, a temperature of the lubricant in the pressure accumulator may be maintained such that hot lubricant from when the engine was previously operating may flow to engine upon a subsequent restart. This may reduce a cold-start duration, thereby decreasing cold-start emissions.

If the engine stop is not upcoming, then the method **1000** may proceed to **1008** to determine if the engine is stopped. The engine is stopped if the engine is one or more of not being fueled and not spinning.

If the engine is stopped, then the method **1000** may proceed to **1010** to determine if an engine start is upcoming. An engine start may be upcoming if the brake pedal is released (e.g., inclined) and/or if the accelerator pedal is depressed (e.g., declined). Additionally or alternatively, the engine start may be upcoming if a key is inserted into an ignition or if an ignition button is depressed. Furthermore, the engine start may be upcoming if a user enters the driver's portion of the car and sits in the driver's seat. Still further, the upcoming engine start may be determined by a navigation system monitoring a traffic light changing from stop to go or determining a time of day that a user generally begins using the car. For example, if a user begins driving at 7:00 am on average daily, then the navigation system may determine the engine start is upcoming at 6:59 am.

If the engine start is upcoming, then the method **1000** may proceed to **1012** to flow lubricant from the pressure accumulator to the engine prior to the engine start. In one example, prior to the engine start may be based on a threshold time (e.g., 15 seconds) before the start. The threshold time may be based on an amount of time needed for the pressure accumulator to sufficiently lubricate the engine. Additionally or alternatively, the threshold time before the engine start may be adjusted based on a pressure of the pressure accumulator, where the threshold time decreases as the pressure of the pressure accumulator increases. For example, the threshold time corresponding to a pressure equal to the fifth pressure P**5** is less than the threshold time corresponding to a pressure less than the third pressure P**3**. This may be due to a higher lubricant flow rate of a pressure accumulator having a higher pressure compared to a lower pressure. To flow the lubricant from the pressure accumulator to the engine, one or more of the two-way valve in the accumulator line is opened and the two-way valve in the circulation line is opened. In one example, only the accumulator line two-way valve is opened and the two-way valve in the circulation line remains closed. Due to the thermal insulation of the pressure accumulator, a temperature of the lubricant flowing from the pressure accumulator to the engine prior to the upcoming engine start is hotter than an engine temperature. By doing this, the engine may be warmed-up to a temperature closer to a desired operating temperature.

Returning to **1008** and **1010**, if the engine is not stopped or the engine start is not upcoming, respectively, then the method **1000** proceeds to **1014** to maintain current engine operating parameters. In one example, the method **900** of FIG. **9** is followed.

In this way, a pressure accumulator is configured to maintain a desired pressure range. The technical effect of maintain the desired pressure range is to allow the pressure accumulator to flow lubricant to the engine during engine off conditions or during conditions where it would be desired to shut-off the pump. Additionally, by thermally insulating the pressure accumulator, the pressure accumulator may deliver hot lubricant to the engine during engine off conditions when hot lubricant is otherwise unavailable.

An embodiment of an oil supply unit comprises a collecting vessel for collecting oil, a feed line which leads from the collecting vessel to an engine which is to be supplied with oil, a pump which is arranged in the feed line, a return line which leads from the engine to the collecting vessel, and a circulation line which leads from the feed line to the collecting vessel, further comprising a pressure accumulator which is connected via an accumulator line to the feed line, the pressure accumulator being thermally insulated and a two-way valve which can be switched in dependence of a pressure which prevails in the feed line, wherein the two-way valve is in a first switched position in the case of a first pressure and is in a second switched position in the case of a second pressure which is higher than the first pressure, wherein the circulation line is shut off in the first switched position of the two-way valve and is opened in the second switched position of the two-way valve. A first example of the oil supply unit further comprises where a pump has a constant displacement capacity. A second example of the oil supply unit, optionally including the first example, further includes where the two-way valve is a two/two-way valve which is arranged in the circulation line. A third example of the oil supply unit, optionally including the first and/or second examples, further includes where the two-way valve is a three/two-way valve which is arranged in the feed line and to which is connected the circulation line. A fourth example of the oil supply unit, optionally including one or more of the first through third examples, further includes where the accumulator line comprises an accumulator line two-way valve, wherein the accumulator line is fluidly coupled to the feed line in a first switched position of the accumulator-line two-way valve and fluidly sealed from the feed line in a second switched position of the accumulator-line two-way valve. A fifth example of the oil supply unit, optionally including one or more of the first through fourth examples, further includes where the pump is driven by the engine and the pump is functionally connected to the engine via a clutch, and where the clutch is operated in dependence of an oil pressure of the oil supply unit. A sixth example of the oil supply unit, optionally including one or more of the first through fifth examples, further includes where the pump is driven by an electric motor, the electric motor configured to be adjusted via a controller comprising computer-readable instructions stored on memory thereon that when executed enable the controller to switch the electric motor between on and off positions based on an oil pressure of the oil supply unit. A seventh example of the oil supply unit, optionally including one or more of the first through sixth examples, further includes where the accumulator line further comprises an accumulator-line check valve configured to shut off an inflow to the pressure accumulator, and a bypass configured to circumvent the accumulator-line check valve via a bypass restrictor.

An embodiment of a system comprises a collecting vessel for storing lubricant being fluidly coupled to a feed line and a circulation line, a pump and an engine being arranged along the feed line, an accumulator line fluidly coupled to both the feed and circulation lines, and a pressure accumulator arranged along the accumulator line, the pressure accumulator configured to store lubricant at a pressure independent of a pressure of the feed line, and where the pressure accumulator comprises thermal insulation. A first example of the system further includes where the thermal insulation is an insulating material comprising one or more of rubber, ceramic, and metal. A second example of the system, optionally including the first example, further includes where the circulation line fluidly couples the pressure accumulator to the collecting vessel, and where the circulation line comprises a two-way valve configured to fluidly couple and fluidly seal the pressure accumulator from the collecting vessel. A third example of the system, optionally including the first and/or second examples further includes where the pressure accumulator receives lubricant when a pressure of the pressure accumulator is less than a lower threshold and where the pressure accumulator does not receive lubricant when the pressure of the pressure accumulator is greater than an upper threshold, where the upper threshold is equal to a pressure greater than a pressure equal to the lower threshold. A fourth example of the system, optionally including one or more of the first through third examples, further includes where the pressure accumulator flows lubricant to the engine when the pressure of the pressure accumulator is greater than the lower threshold. A fifth example of the system, optionally including one or more of the first through fourth examples, further includes where the accumulator comprises an accumulator line two-way valve, the accumulator line two-way valve configured to fluidly couple and fluidly seal the pressure accumulator from the feed line. A sixth example of the system, optionally including one or more of the first through fifth examples, further includes where comprising a controller with computer-readable instruction stored thereon that when executed enable the controller to close the accumulator line two-way valve in response to an upcoming engine stop, and open the accumulator line two-way valve in response to an upcoming engine start.

An embodiment of a method comprises flowing lubricant from a lubricant supply unit to a pressure accumulator, the pressure accumulator comprising a thermal insulation and maintaining a pressure of the lubricant in the pressure accumulator during an engine off. A first example of the method further includes where maintaining the pressure of the lubricant in the pressure accumulator further comprises adjusting a two-way valve to a closed position to fluidly seal the pressure accumulator from the lubricant supply unit in response to an upcoming engine off, where the upcoming engine off prior to the engine off by a threshold time. A second example of the method, optionally including the first example, further includes where adjusting the two-way valve to an open position during the engine off and prior to an engine start to prematurely flow lubricant from the pressure accumulator to an engine, where the open position fluidly couples the pressure accumulator to the lubricant supply unit. A third example of the method, optionally including the first and/or second examples, further includes where the flowing occurs in response to a pressure of the pressure accumulator being less than a lower threshold, where the lower threshold is based on a fill of the pressure accumulator. A fourth example of the method, optionally including one or more of the first through third examples, further includes where the lubricant supply unit comprises a pump, and where the pump and the pressure accumulator are configured to flow lubricant to an engine arranged along the feed line.

Although the disclosure has been fully illustrated and described in detail by means of the exemplary embodiments, the disclosure is not limited by the disclosed examples and other variations can be derived by the person skilled in the art without departing from the extent of protection of the disclosure.

The figures are not necessarily true to detail and true to scale and can be represented in an enlarged or downsized form in order to provide a better overview. Therefore, in this case, disclosed functional details are not to be understood as being limiting but only as a descriptive basis which offers the person skilled in the art guidance in this field of technology in order to use the present disclosure in a diverse manner.

The expression “and/or” used here, if it is used in a number of two or more elements, means that each of the described elements can be used alone or each combination of two or more of the described elements can be used. If for example a composition is described, wherein it contains the components A, B and/or C, the composition can contain A alone; B alone; C alone; A and B in combination; A and C in combination; B and C in combination; or A, B and C in combination.

Note that the example control and estimation routines included herein can be used with various engine and/or vehicle system configurations. The control methods and routines disclosed herein may be stored as executable instructions in non-transitory memory and may be carried out by the control system including the controller in combination with the various sensors, actuators, and other engine hardware. The specific routines described herein may represent one or more of any number of processing strategies such as event-driven, interrupt-driven, multi-tasking, multi-threading, and the like. As such, various actions, operations, and/or functions illustrated may be performed in the sequence illustrated, in parallel, or in some cases omitted. Likewise, the order of processing is not necessarily required to achieve the features and advantages of the example embodiments described herein, but is provided for ease of illustration and description. One or more of the illustrated actions, operations and/or functions may be repeatedly performed depending on the particular strategy being used. Further, the described actions, operations and/or functions may graphically represent code to be programmed into non-transitory memory of the computer readable storage medium in the engine control system, where the described actions are carried out by executing the instructions in a system including the various engine hardware components in combination with the electronic controller.

It will be appreciated that the configurations and routines disclosed herein are exemplary in nature, and that these specific embodiments are not to be considered in a limiting sense, because numerous variations are possible. For example, the above technology can be applied to V-6, I-3, I-4, I-6, V-12, opposed 4, and other engine types. The subject matter of the present disclosure includes all novel and non-obvious combinations and sub-combinations of the various systems and configurations, and other features, functions, and/or properties disclosed herein.

The following claims particularly point out certain combinations and sub-combinations regarded as novel and non-obvious. These claims may refer to "an" element or "a first" element or the equivalent thereof. Such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements. Other combinations and sub-combinations of the disclosed features, functions, elements, and/or properties may be claimed through amendment of the present claims or through presentation of new claims in this or a related application. Such claims, whether broader, narrower, equal, or different in scope to the original claims, also are regarded as included within the subject matter of the present disclosure.

The invention claimed is:

1. An oil supply unit comprising:

a collecting vessel for collecting oil, a feed line which leads from the collecting vessel to an engine which is to be supplied with oil, a pump which is arranged in the feed line, a return line which leads from the engine to the collecting vessel, a circulation line comprising a first two-way valve, which leads from the feed line to the collecting vessel, and a control line connecting the feed line and the first two-way valve, further comprising a pressure accumulator which is connected via an accumulator line to the feed line;

wherein the first two-way valve which can be switched in dependence of a pressure which prevails in the feed line, wherein the first two-way valve is in a first switched position in the case of a first pressure and is in a second switched position in the case of a second pressure which is higher than the first pressure, wherein the circulation line is shut off in the first switched position of the first two-way valve and is opened in the second switched position of the first two-way valve;

a second two-way valve coupled to the accumulator line; and

a controller storing instructions in non-transitory memory that, when executed, cause the controller to:

in response to an engine-off condition, close the second two-way valve, and in response to an upcoming engine start, open the second valve a threshold time prior to the upcoming engine start and close the first valve to flow lubricant from the pressure accumulator to the engine, the threshold time adjusted based on a pressure of the pressure accumulator, wherein a temperature of the lubricant flowing from the pressure accumulator to the engine is hotter than an engine temperature.

2. The oil supply unit of claim **1**, wherein the pump has a constant displacement capacity and where the pressure accumulator is thermally insulated.

3. The oil supply unit of claim **2**, wherein the pressure accumulator is thermally insulated via a combination of air and water.

4. The oil supply unit of claim **1**, wherein the accumulator line is fluidly coupled to the feed line in the first switched position of the second two-way valve and fluidly sealed from the feed line in the second switched position of the second two-way valve.

5. The oil supply unit of claim **1**, wherein the pump is driven by the engine and the pump is functionally connected to the engine via a clutch, and where the clutch is operated in dependence of an oil pressure of the oil supply unit.

6. The oil supply unit of claim **1**, wherein the pump is driven by an electric motor, the electric motor configured to be adjusted via the controller comprising computer-readable instructions stored on memory thereon that when executed cause the controller to switch the electric motor between on and off positions based on an oil pressure of the oil supply unit.

7. The oil supply unit of claim **1**, wherein the accumulator line further comprises an accumulator-line check valve configured to shut off an inflow to the pressure accumulator, and a bypass configured to circumvent the accumulator-line check valve via a bypass restrictor.

8. A system comprising:

a collecting vessel for storing lubricant being fluidly coupled to a feed line and a circulation line, a pump and an engine being arranged along the feed line, wherein the circulation line comprises a first valve;

an accumulator line fluidly coupled to both the feed and circulation lines, the accumulator line comprising a second valve;

a pressure accumulator arranged along the accumulator line, the pressure accumulator configured to store lubricant at a pressure independent of a pressure of the feed line, and where the pressure accumulator comprises thermal insulation; and

a controller storing instructions in non-transitory memory that, when executed, cause the controller to:

in response to an engine-off condition, close the second valve to maintain a temperature of the lubricant, and in response to an upcoming engine start, open the second valve a threshold time prior to the upcoming engine start and close the first valve to flow hot lubricant from the pressure accumulator to the engine, the threshold time decreasing with an increase in a pressure of the pressure accumulator.

9. The system of claim **8**, wherein the thermal insulation is an insulating material comprising one or more of rubber, ceramic, and metal.

10. The system of claim **8**, wherein the circulation line fluidly couples the pressure accumulator to the collecting vessel, and where the first valve is a two-way valve configured to fluidly couple and fluidly seal the pressure accumulator from the collecting vessel.

11. The system of claim **8**, wherein the pressure accumulator receives lubricant when the pressure of the pressure accumulator is less than a lower threshold and where the pressure accumulator does not receive lubricant when the pressure of the pressure accumulator is greater than an upper threshold, where the upper threshold is equal to a pressure greater than a pressure equal to the lower threshold.

12. The system of claim **11**, wherein the pressure accumulator flows lubricant to the engine when the pressure of the pressure accumulator is greater than the lower threshold.

13. The system of claim **8**, wherein the second valve is configured to fluidly couple and fluidly seal the pressure accumulator from the feed line.

14. A method comprising:

flowing lubricant from a pump to a pressure accumulator through a feed line, the pressure accumulator comprising a thermal insulation; and

maintaining a pressure of the lubricant in the pressure accumulator during an engine off;

wherein maintaining the pressure of the lubricant in the pressure accumulator further comprises adjusting a second two-way valve in an accumulator line to a closed position to fluidly seal the pressure accumulator from the feed line in response to an upcoming engine off, where the upcoming engine off is prior to the engine off by a threshold time; and

in response to an upcoming engine start, opening the second two-way valve another threshold time prior to the upcoming engine start while maintaining a first two-way valve coupled to the circulation line closed to flow hot lubricant from the pressure accumulator directly to the engine, the another threshold time adjusted based on a pressure of the pressure accumulator.

15. The method of claim **14**, wherein the flowing lubricant from the pump to the pressure accumulator occurs in response to a pressure of the pressure accumulator being less than a lower threshold, where the lower threshold is based on a fill of the pressure accumulator.

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